

Sulfur and strontium isotope study of hydrothermal mineralization from the SE Afar Rift

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Epithermal mineralization was recently described in the SE Afar Rift (Republic of Djibouti). To infer fluid sources in hydrothermal veins, sulfur and strontium isotopic analyses were performed on thirty mineralized samples of chalcedony, and/or quartz, ± carbonate containing gold and sulfides. Gypsum occurs as individual mounds and shallow stockwork zones. Isotopic composition of sulfides and sulfates were determined using Multicollector-Inductively Coupled Plasma Mass Spectrometer (MC ICPMS) and Thermal Ionisation Mass Spectrometer (TIMS) methods [1]. Sulfur isotopic composition of sulfides (mainly pyrite) vary from -0.2 to +6.8‰. These values are classically reported for volcanic rocks and hydrothermal sources. Strontium isotopic ratios (⁸⁷Sr/⁸⁶Sr) of mineralized veins range from 0.70391 to 0.70799. The lowest values of ⁸⁷Sr/⁸⁶Sr ratios indicate volcanic source of fluid while the highest isotopic composition indicate significant seawater contribution (defined at 0.70903, [2]). Coupled sulfur and strontium isotope compositions of eight sulfate samples hosted in (i) gypsum mound; (ii) evaporites (iii) stockwork veins in sediment or in volcanic rocks were also investigated to characterize the sources of Sr and S. The δ³⁴S values of the sulfate range from -1 to +14.3‰ while the ⁸⁷Sr/⁸⁶Sr compositions fall in the range 0.70389-0.70639. The highest values of ⁸⁷Sr/⁸⁶Sr ratios (0.70639) in gypsum correspond to the lighter values of δ³⁴S (+14.3‰). These relatively light δ³⁴S values can be explained by the disproportionation of magmatic SO₂. This implies that both acidic fluid of magmatic origin and saline fluids contribute to the hydrothermal system in the Afar Rift.

[1] Craddock *et al.* (2008) *Chem. Geol.* **253**, 102–113.

[2] Barrat *et al.* (1993) *GCA* **57**, 2291–2302.

Isotopic fractionation of zinc in planetary basalts

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Zinc is a moderately volatile chalcophile trace element and so preserves evidence for volatility-driven processes during planetary accretion. For this reason, Zn can be used to understand the origin and evolution of planetary bodies, including Earth-Moon system formation. Terrestrial igneous rocks exhibit a limited range in zinc isotopic composition (δ⁶⁶Zn = +0.3±0.1‰, 2SE), whereas large variations have been found in lunar soils (δ⁶⁶Zn up to +6.4‰ [1]) and tektites (up to +2.04‰ [2]) associated with volatilization processes.

Here we report new Zn isotopic data for low- and high-Ti mare basalts to directly address the origin of the Earth and Moon. We also present new Zn isotopic data for martian meteorites, which have identical Zn isotopic compositions, within uncertainties (δ⁶⁶Zn = +0.25±0.03‰, 2SE, n=10), to terrestrial lavas. Absolute Zn concentrations in mare basalts (0.6-12ppm) are generally significantly lower than for terrestrial lavas (typically >75ppm), silicate Earth estimates (~55ppm), CI chondrites (>300ppm), or lunar pyroclastic beads (>90ppm) [1]. With the exception of two outliers, low-Ti and the high-Ti lunar basalts have similar mean δ⁶⁶Zn values of +1.31±0.13‰ (n=11) and +1.39±0.31‰ (n=8), respectively, and similar ranges (+0.8 to +1.6‰ and +0.5 to +1.9‰, respectively). By comparison, lunar regolith materials have higher δ⁶⁶Zn values due to micrometeorite impacts and/or cosmic ray sputtering, and lunar pyroclastic beads are enriched in light isotopes (-3.7±0.3‰ [1,3]).

Zinc isotopic homogeneity in terrestrial and martian igneous rocks and lack of obvious isotopic fractionation of Zn in low- and high-Ti mare basalts (versus O or Fe [4]) suggest that igneous processes do not fractionated Zn isotopes significantly. Values of δ⁶⁶Zn were probably not inherited from the proto-Earth (for Earth) or Theia (for the Moon) because chondrite meteorites have lower δ⁶⁶Zn (<0.8‰) than mare basalts [5]. Instead, enrichments in heavy Zn isotopes for mare basalts are likely a consequence of degassing either following giant impact, or during basaltic eruption. Alternatively, Zn isotopic fractionation during giant impact, followed by stochastic late accretion [6,7] led to the Zn isotopic compositions seen in terrestrial, martian and lunar igneous rocks.

[1] Herzog (2009) *GCA* **73**, 5884. [2] Moynier (2009) *EPSL* **277**, 482. [3] Moynier (2006) *GCA* **70**, 6103. [4] Liu (2010) *GCA* **74**, 6249. [5] Luck (2005) *GCA* **69**, 535. [6] Botke (2010) *Science* **330**, 1527. [7] Albarede (2009) *Nature* **461**, 1227.